

## CLAIMS

### What is claimed is:

- 5     1.     A method for providing parallel execution of computing tasks in a heterogeneous computing environment comprising:

partitioning a computing task into small tasks;

- 10     assigning the small tasks to mobile agents;

determining available computing hosts in the heterogeneous computing environment;

transferring the mobile agents to the available computing hosts; and

- 15     executing the mobile agents at the available computing hosts using the execution code.

2.     The method of claim 1, wherein the step of determining available computing hosts further comprises determining network latency.

- 20     3.     The method of claim 1, further comprising transferring execution code from a central server to virtual machines at the available computing hosts

4.     The method of claim 1, wherein the step of executing the mobile agents is performed in  
25     virtual machines at the computing hosts without modification of the virtual machines.

5. The method of claim 1, wherein one of the small tasks is assigned to one of the mobile agents.

5 6. The method of claim 3, wherein the step of transferring execution code is performed in response to a request by a mobile agent.

7. The method of claim 6, wherein the step of transferring execution code is performed by a web server.

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8. The method of claim 1 further comprising monitoring execution of the mobile agents at the available computing hosts.

9. The method of claim 1 further comprising allowing the mobile agents to collaborate over  
15 the heterogeneous computing environment as the mobile agents execute at the available computing hosts.

10. The method of claim 1, wherein the mobile agents are executed in real time.

11. A method for providing parallel computing using mobile agents comprising:

breaking a computer task into small tasks;

5 assigning the small tasks to mobile agents;

transferring the mobile agents to computing hosts;

transferring execution code from a central server to computing hosts;

10 executing the mobile agents at the computing hosts using the execution code; and

storing real-time state information about the mobile agents as the mobile agents execute  
at the computing hosts.

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12. The method of claim 11 further comprising, prior to transferring the mobile agents, the steps of:

determining network latency affecting transmission of data between computing hosts; and

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halting transferring of the mobile agents if network latency exceeds a threshold.

13. The method of claim 12 further comprising, prior to transferring the mobile agents, the steps of:

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monitoring utilization of the computing hosts; and

halting transferring of the mobile agents if utilization of computing hosts exceeds a threshold.

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14. A method for migrating an application in a virtual machine from a primary host to a secondary host comprising:

constructing an application using at least one mobile agent;

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detecting an indication to migrate the application;

in response to the indication, migrating the application from the primary host to the secondary host without modifying a virtual machine.

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15. The method of claim 14 wherein the indication comprises an indication of network latency.

16. The method of claim 14 wherein the indication comprises an indication of hostile attack.

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17. The method of claim 16 wherein the hostile attack comprises hacking.

18. The method of claim 14 wherein the indication comprises an indication of network failure.

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19. The method of claim 14 wherein the indication comprises an indication of computer hardware failure.

20. The method of claim 14 further comprising resuming execution of the mobile agent at the secondary host where execution was halted.

21. The method of claim 20, wherein information about the mobile agent is used to resume  
5 execution of the mobile agent, the information about a mobile agent comprising information about an execution thread of the mobile agent as it existed at a computing host prior to being transferred to the secondary computing host, the information being reconstructed at the secondary computing host after the mobile agent is transferred to the secondary computing host.

10 22. The method of claim 21 wherein the information about the mobile agent thread comprises stack trace information.

23. The method of claim 21 wherein the information about the mobile agent thread comprises state information.

15 24. The method of claim 22 wherein the information about the mobile agent thread further comprises state information.

25. The method of claim 14 further comprising:

20 continuing monitoring for another indication to migrate the application;

continuing migrating the application to other hosts.

26. A computer system apparatus for providing parallel execution of computing tasks in a heterogeneous network comprising:

a dispatcher for partitioning the computing task into a plurality of small tasks and

5 dispatching the small tasks;

mobile agents for receiving small tasks from the dispatcher;

computing resources on a network including virtual machines;

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means for transferring the mobile agents to the computing resources; and

means for transferring execution code from a central server to the computing resources,  
the computing resources receiving and executing one of the small tasks assigned to a mobile  
15 agent in the virtual machines using the execution code.

27. The apparatus of claim 26, further comprising a debugger for monitoring execution of the small tasks, the debugger storing stack trace and state information for each of the small tasks as each of the small tasks is executed by the computing services.

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28. The apparatus of claim 26 wherein the central server comprises a web server.

29. The apparatus of claim 26 further comprising means for monitoring execution of the small tasks.

30. The apparatus of claim 26 further comprising collaboration means for allowing the  
5 mobile agents to communicate and share information in real time.

31. The apparatus of claim 26, wherein the mobile agents execute in real time.

32. The apparatus of claim 26, further comprising storage means for storing real time state  
10 information about the mobile agents as the mobile agents execute at the computing resources.

33. The apparatus of claim 26 further comprising:

means for monitoring execution of the mobile agents at the computing hosts; and  
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means for detecting over-utilization of one of the computing hosts and for issuing a  
warning when one of the computing hosts is over-utilized.



34. A method for providing realistic thread migration which comprises:

instantiating a mobile agent thread at a first computing host;

5 processing the mobile agent thread at the first computing host;

storing information about the mobile agent thread as the mobile agent thread is executed;

detecting an indication to migrate the mobile agent thread; and

10 in response to the indication,

stopping execution of the mobile agent thread; and

15 transferring the information about the mobile agent thread to a second computing host.

35. The method of claim 34 wherein the information about the mobile agent thread comprises stack trace information.

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36. The method of claim 34 wherein the information about the mobile agent thread comprises state information.

37. The method of claim 35 wherein the information about the mobile agent thread further comprises state information.

38. The method of claim 30 further comprising:

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receiving the information about the mobile agent thread at the second host;

reconstructing the mobile agent thread at the second host using the information about the mobile agent thread; and

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continuing processing of the mobile agent thread at the second host at a point at which execution of the thread was stopped at the first host.

39. The method of claim 38 wherein the step of transferring the information about the mobile agent thread further comprises serializing the information about the mobile agent thread.

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40. An agent collaboration environment which comprises:

a plurality of mobile agents;

5 a conference room for providing a virtual workspace for the mobile agents; and

a registration subsystem for selectively assigning the plurality of mobile agents to the conference room,

10 wherein each of the plurality of agents can share data, information, and results of computations in the conference room.

41. The agent collaboration environment of claim 40, wherein the conference room monitors  
15 and moderates communication between the plurality of mobile agents.